

heat-treating the conductive barrier film in the atmosphere including nitrogen, hydrogen, or combinations thereof.

[0021] In some example embodiments, the forming a composition-changed conductive barrier film may include exposing the conductive barrier film to ultraviolet (UV) radiation.

[0022] In some example embodiments, the forming a metal plug may include forming a metal seed layer on the composition-changed conductive barrier film, forming a metal filling layer on the metal seed layer, the metal filling layer filling the contact hole, and reflowing the metal seed layer and the metal filling layer.

[0023] In some example embodiments, the forming a metal seed layer may include forming the metal seed layer to discontinuously extend on the composition-changed conductive barrier film such that a portion of the composition-changed conductive barrier film is exposed by the metal seed layer.

[0024] In some example embodiments, the method further includes post-treating a result product including the metal seed layer in a nitrogen-containing gas atmosphere, a hydrogen-containing gas atmosphere, or combinations thereof. The post-treating may be performed before the forming of the metal filling layer and after the forming of the metal seed layer.

[0025] In some example embodiments, the post-treating may include plasma-treating the result product.

[0026] In some example embodiments, the post-treating may include plasma-treating the result product by using a gas activated in a form of direct plasma.

[0027] In some example embodiments, the post-treating may include heat-treating the result product at a temperature of about 300° C. to about 1000° C.

[0028] In some example embodiments, the method may further include pre-treating an exposed surface of the conductive barrier film in a nitrogen-containing gas atmosphere, a hydrogen-containing gas atmosphere, or combinations thereof. The pre-treating may be performed after the forming a conductive barrier film and before the forming a metal silicide film.

[0029] In some example embodiments, the pre-treating may include plasma-treating the exposed surface of the conductive barrier film.

[0030] In some example embodiments, the pre-treating may include plasma-treating the exposed surface of the conductive barrier film by using a gas activated in a form of direct plasma.

[0031] In some example embodiments, the pre-treating may include heat-treating the exposed surface of the conductive barrier film at a temperature of about 300° C. to about 1000° C.

[0032] In some example embodiments, the forming a composition-changed conductive barrier film may include forming an N-rich metal nitride film.

[0033] According to an example embodiment, a method of fabricating an integrated circuit device includes forming a gate line and a plurality of source/drain regions on at least one fin-shaped active region, the plurality of source/drain regions being arranged at both sides of the gate line, forming an insulating film which covers the at least one fin-shaped active region, the gate line, and the plurality of source/drain regions, forming at least one contact hole to penetrate the insulating film and expose at least one source/drain region among the plurality of source/drain regions, forming a metal

film in the contact hole such that the metal film contacts the at least one source/drain region, forming a conductive barrier film on the metal film to cover an inner wall of the contact hole, forming a metal silicide film by performing silicidation of at least a portion of the metal film using a silicidation atmosphere while the conductive barrier film is exposed to the silicidation atmosphere, forming a composition-changed conductive barrier film by treating the conductive barrier film in a first atmosphere including at least one of nitrogen and hydrogen, while covering the metal silicide film with the conductive barrier film, forming a metal seed layer to discontinuously extend on the composition-changed conductive barrier film such that the metal seed layer is exposed by the composition-changed conductive barrier film, post-treating the composition-changed conductive barrier film and the metal seed layer in a second atmosphere including at least one of nitrogen and hydrogen, and forming a metal filling layer on the post-treated metal seed layer to fill the contact hole.

[0034] In some example embodiment, the forming a composition-changed conductive barrier film may include exposing the conductive barrier film to any one of plasma, heat, and UV radiation.

[0035] In some example embodiment, the method may further include pre-treating an exposed surface of the conductive barrier film in an atmosphere comprising at least one of nitrogen and hydrogen. The pre-treating may be performed before the forming a metal silicide film and after the forming a conductive barrier film.

[0036] In some example embodiment, at least one of the pre-treating and the post-treating may include treating using any one of plasma, heat, or UV radiation.

[0037] In some example embodiment, when the at least one fin-shaped active region comprises a plurality of fin-shaped active areas extending parallel to each other, the plurality of source/drain regions may be on the plurality of fin-shaped active areas, the at least one contact hole may include a plurality of contact holes, and the contact holes expose the plurality of source/drain regions on the plurality of fin-shaped active areas, respectively, and the forming the metal film may include forming the metal film to contact the plurality of source/drain regions.

[0038] In some example embodiment, the method may further include reflowing the metal seed layer and the metal filling layer by annealing the metal seed layer and the metal filling layer.

[0039] According to an example embodiment, a method of fabricating an integrated circuit device includes forming an insulating film on a substrate having a conductive region, forming a contact hole to penetrate the insulating film and expose the conductive region, forming a metal film in the contact hole such that the metal film contacts the conductive region, forming a conductive barrier film on the metal film to cover an inner wall of the contact hole, forming a metal silicide film by performing silicidation of at least a portion of the metal film using a silicidation atmosphere while the conductive barrier film is exposed to the silicidation atmosphere, forming a composition-changed conductive barrier film by treating the conductive barrier film in an atmosphere including at least one of nitrogen and hydrogen, while covering the metal silicide film with the conductive barrier film in a first chamber, the first chamber selected from among a plurality of process chambers of a cluster tool, and